



## Chaire Banque de marchés de demain : enjeux modélisation et calcul

Academic partner(s) : LPSM laboratory / Université Paris Cité

Financial partner(s) : Crédit Agricole Corporate and Investment Bank

Scientific director(s) : Stéphane Crépey

Website : <https://www.institutlouisbachelier.org/en/programme/capital-markets-tomorrow-modeling-and-computational-issues/>

## RESEARCH PROGRAM DESCRIPTION

The numerical toolbox of market finance traditionally rests on three pillars: (i) approximate formulas, (ii) deterministic numerical schemes, and (iii) simulation methods. (i) includes Fourier transform formulas in affine jump diffusion models, or asymptotic calculations such as the ones for the implied volatility in the SABR model. (ii) are difference or finite element techniques for the financial derivatives pricing and greeking PDEs. (iii) are based on the Feynman-Kac type probabilistic representation of the solutions of these PDEs, or (in nonlinear cases) on the probabilistic formulation of these PDEs as backward stochastic differential equations (BDSDEs).

The chair primarily concerns probabilistic machine learning, in the sense of statistical learning methods on simulated data in finance. Learning is then conceived, not as a way of modelling from data (since the data are simulated within a predefined model or class of models), but as a fourth term in the previous toolbox. Quantitative finance indeed offers a vast field of application for statistical learning techniques, implemented on simulated data. This is again a well-established tradition, originating in the numerical simulation/regression schemes for pricing Bermuda options à la Longstaff and Schwarz, which have since been considerably extended to BSDEs. Nevertheless, we can speak of a recent technological breakthrough in this field, which has been disrupted by the flood of machine learning techniques.

Following the increasing burden of the regulation since the global financial crisis of 2007-09, banks are subject to a very large number of risk measurement calculations. They are also required to calculate various XVA metrics, i.e. valuation adjustments to account for counterparty risk and its consequences in terms of capital and collateral costs. These calculations must be carried out at different levels of aggregation: the bank's netting sets (client portfolios), the broader level of funding sets for funding cost calculations, and the bank's balance sheet as a whole for economic capital and cost of capital calculations. The chair is situated at the meeting point between these increased computational needs of investment banks and the explosion of machine learning techniques. Beyond the calculation challenges posed by the evolution of the regulation, the latter also raises numerous questions in terms of modeling and model risk.

We also look at other possible applications of machine learning in finance, this time involving historical data (as opposed to simulated data above). The challenges are then multiple and arduous: non-stationarity of financial data, problems of large dimensions, small and missing data, extremes and dependence in the tails of distributions (in connection for example with risk measures)

## RESEARCH TEAM

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### Researchers

Lokman ABBAS TURKI, Assistant Professor Sorbonne Université

David BARRERA, Assistant Professor Universidad de los Andes (Colombie)

Stéphane CREPEY, Professor Université Paris Cité

Eduardo ABI JABER, Assistant Professor Ecole Polytechnique

Cyril BÉNEZET, Assistant Professor ENSIIE / LaMME Paris Saclay

Bouazza SAADEDDINE, Quantitative Researcher at Crédit Agricole CIB

Moritz VOSS, Assistant Professor UCLA (USA)

### Postdoctoral Researchers

Botao LI, Postdoc Université Paris Cité (since May 2023), co-funded by the Chair and the ILB Labex

### PhD Students

Aurélien GRENARD, CIFRE PhD student (since Oct 2022) on “Learning distributions”, Sorbonne Université and Christophe Michel’s CACIB team, funded by a CIFRE coming on top of the chair

**Published**

Abbas-Turki, L., S. Crépey, and B. Saadeddine. Pathwise CVA regressions with oversimulated Defaults. *Mathematical Finance* 2(33), 274–307, 2023.

**Under review:** All the workings papers below, and

Crépey, S.. Invariance times transfer properties.

Li, B., S. Crépey, H. D. Nguyen, and B. Saadeddine. CVA learning, PnL explain, and hedging.

**Working papers**

Abbas-Turki, L., B. Alexandrine, and Q. Li. Polynomial Distribution of Feedforward Neural Network Output, hal-04217029, September 2023

Abbas-Turki, and Q. Li. Global Random Maximization of Feedforward Neural Network, hal-04276320, October 2023.

Albanese, C., C. Benezet, and S. Crépey. Hedging valuation adjustment and model risk. arXiv:2205.11834v2, December 2023.

Benezet, C., S. Crépey and D. Essaket. Hedging valuation adjustment for callable claims. arXiv:2304.02479v1, April 2023.

Crépey, S., N. Frikha, and A. Louzi. A multilevel stochastic approximation algorithm for unbiased value-at-risk and expected shortfall estimation. arXiv:2304.01207, March 2023.

Crépey, S., N. Frikha, A. Louzi, and G. Pagès. Asymptotic error analysis of multilevel stochastic approximations for the value-at-risk and expected shortfall. arXiv:2311.15333, November 2023.

## MAJOR COMMUNICATIONS RELATED TO THE RESEARCH PROGRAM

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### Major academic conferences, invited speaker, etc.

Stéphane Crépey (*invited speaker* \*):

Dec 23 Quant Summit Europe, Londres (\*).

Nov 23 Quantminds 2023, Londres (\*).

June 23 MathRisk Conference on Numerical Methods in Finance, Udine (Italy).

April 23 Quantitative finance workshop 2023, Gaeta (Italy).

March 23 Risk measurement day, Natixis.

Lokman ABBAS TURKI (*invited speaker* \*):

June 23 Probability & Mathematical Physics, UCLA (\*).

### Events organized by the program

Morning of the Chaire CMT, October 26 2023, at CACIB (Montrouge).  
<https://www.linkedin.com/feed/update/urn:li:activity:7123580082207477760/>

Contribution (3000 euros) to the Bachelier colloquium of January 2024 <https://colloque-bachelier24.sciencesconf.org/> , <https://colloque-bachelier24.sciencesconf.org/resource/sponsors>

Contribution (3000 euros) to the Colloque des Jeunes Probabilistes et Statisticiens 2023  
<https://jps-2023.sciencesconf.org/> , <https://jps-2023.sciencesconf.org/resource/sponsors> .

**Awards, scientific recognition, organization of calls for projects, involvement in master's courses, PhD program visiting researchers, etc...**

Stéphane Crépey delivers a 12h course *Deep XVA analysis* completed by a python colab tutorial of Bouazza Saadeddine in the context of master M2MO 'Laure Elie' <https://masterfinance.math.univ-paris-diderot.fr/>

Lokman Abbas Turki was awarded a ~16k euros grant from the European Master for HPC program to prepare the MOOC [Massive Parallel Programming on GPUs and Applications](#). This GPU course is taught each year to more than 150 master students in mathematics and computer science. The MOOC can be found on the EUMaster4HPC website below.

[European Master For High Performance Computing - Student Portal/Teaching Materials \(eumaster4hpc.eu\)](#)

Nicolas Damay, data scientist CACIB in charge of the AI/ML projects for the financial markets, led a group of students of master M2ISIFAR <https://master.math.u-paris.fr/annee/m2-isifar/> on a master project about the exploitation of American insurers' public trading data, with an emphasis on AI explainability.

The chair supports the LPSM laboratory and the UPC department of mathematics: see the corresponding "overheads" in the budget.

***Interactions at the teaching level*** (academic year 2022-23):

Bouazza Saadeddine assists Stéphane Crépey for python colab tutorials in the contexts of the XVA course of master M2MO 'Laure Elie' (3h), see <https://masterfinance.math.univ-paris-diderot.fr/>), and of the derivatives modeling course of master M2ISIFAR (12h).

Nicolas Damay, data scientist CACIB in charge of the AI/ML projects for the financial markets, leads a group of students of master M2ISIFAR on their project about the exploitation of American insurers' public trading data, with an emphasis on AI explainability.

The chair supports the LPSM laboratory as well as the mathematical department of Université Paris Cité: see the corresponding "overheads" in the budget of VI.